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A Comparison of Two Models Research, Development and Acquisition Alternatives Analyzer (RDA3) and Value Added Analysis (VAA)

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IN THIS STUDY TWO MODELS USED BY THE PROGRAMS, ANALYSIS AND EVALUATION DIRECTORATE (PAED), HQDA, TO EVALUATE PROGRAM TRADE-OFFS AMONG RESEARCH, DEVELOPMENT, AND ACQUISITION PROGRAMS COMPETING FOR LIMITED ARMY RESOURCES ARE BRIEFLY DESCRIBED, COMPARED AND THEIR LIKELIHOOD TO PRODUCE SIMILAR RESULTS IS ANALYZED.

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A Comparison of Two Models:
Research, Development & Acquisition Alternatives Analyzer (RDA3)
and
Value Added Analysis (VAA)

Captain George B. Hull

A TECHNICAL REPORT
OF THE
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Director, Operations Research Center

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Vita

Captain George B. Hull was born in Mineralwells, Texas in 1956. He entered the Army in 1974, serving for four years before leaving active service to attend college. In 1981 he received a reserve commission and served with the Louisiana Army National Guard. He graduated from Louisiana State University in 1983 with a BS in Zoology and Physiology and reentered active duty with a Regular Army commission. In 1992, he received an MS in Operations Research from the University of Texas at Austin and joined the faculty of the Department of Systems Engineering at the United States Military Academy. After teaching courses in Systems Simulation and Systems Engineering Design he was appointed to a research position in the Operations Research Center, USMA.

Acknowledgements

I would like to thank LTC Andy Loerch of CAA and Dr. Mike Anderson of TRAC-OAC for taking the time to answer my questions and supplying me with information concerning VAA and RDA3. Without their help the comparison of these two models would not have been possible. I would also like to thank LTC Colter and LTC Ramius of PAED who have waited more than patiently for the results of this study.

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Executive Summary

In this study two models used by the Programs, Analysis and Evaluation Directorate (PAED), HQDA, to evaluate program trade-offs among research, development, and acquisition (RDA) programs competing for limited Army resources are briefly described, compared and their likelihood to produce similar results is analyzed. One model, the Research, Development, and Acquisition Alternatives Analyzer (RDA3) was created by TRADOC Analysis Command - Operations Analysis Center (TRAC-OAC). The other model, Value Added Analysis (VAA), was created by Concepts Analysis Agency - Force Systems Directorate. These two models approach the RDA program trade-off problem in somewhat different ways, but both can be used to provide an optimized list of RDA programs which should be included in the Army Program Objective Memorandum (POM) for a given Total Obligation Authority (TOA).

Dr. Ballaschi, Deputy Director of PAED, requested that the Operations Research Center (ORCEN) compare the two models to determine if they would produce contradictory results. His concern was that if both models produce an optimized list of RDA programs for inclusion in the POM, then there should not be significant disagreement between the output of the two models. This study is based on written descriptions of both models and conversations with personnel knowledgeable of each model. The ORCEN did not run each model on a similar set of inputs and subsequently evaluate the output.

RDA3 and VAA were found to have taken substantially different approaches to addressing the problem of recommending an optimum acquisition strategy. Given these differences, it is highly unlikely that RDA3 and VAA would produce extremely similar acquisition strategies. The models differ significantly in their approach. They examine different numbers of systems, they assess relative values of systems differently, they draw cost data from different sources and use it at different levels of detail and they use different mathematical optimization formulations which consider different objective functions and constraints. This constitutes a substantial set of differences in their approach to solving the RDA program trade-off problem.

However, it is possible that there could be substantial agreement between RDA3 and VAA. The principal input into the VAA objective function is the system VAA coefficient or its measure of contribution to force effectiveness as determined in the VAA *Effectiveness Module*. If this measure shows a high correlation with the subjective relative priority weights derived during RDA3's *Phase I* Analytic Hierarchy Process (AHP) survey, then substantial agreement between RDA3 and VAA would be more likely. This agreement assumes that the cost data used by VAA and RDA3, even though drawn from separate sources, is fairly similar. The only method to test this possibility would be to apply both models to the same set of systems and then compare and evaluate the recommended acquisition strategies.

1.0 Problem and Scope of the Study

1.1 Background and Statement of the Problem

The Programs, Analysis and Evaluation Directorate (PAED) must evaluate a large number of research, development, and acquisition (RDA) programs competing for limited Army resources. Traditionally, program development occurs during the Planning, Programming, Budgeting, and Execution System (PPBES) Program Objective Memorandum (POM) building process using functional or mission area panels. These panels have the latitude to establish their own methods for prioritization. The lack of standardization prevents Senior Army Leadership from making the most effective program trade-offs across functional areas.

To provide an enhanced analytical basis for program trade-off decisions, PAED has begun using two models which consider a wide range of factors which affect the RDA cycle for all programs under consideration for inclusion in the Army Program Objective Memorandum (POM). One model, the Research, Development, and Acquisition Alternatives Analyzer (RDA3) was created by TRADOC Analysis Command - Operations Analysis Center (TRAC-OAC). The other model, Value Added Analysis was created by Concepts Analysis Agency - Force Systems Directorate. These two models approach the RDA program trade-off problem in somewhat different ways, but both can be used to provide an optimized list of RDA programs which should be included in the POM for a given Total Obligation Authority (TOA).

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1.2 Scope of the Study

Initial guidance provided to the author was to evaluate the structure of each model and determine if they should reasonably provide similar results. This study is based on written descriptions of both models and conversations with personnel knowledgeable of each model. The ORCEN did not run each model on a similar set of inputs and subsequently evaluate the output. This study does not attempt to identify problems or evaluate the effectiveness of either model nor does it recommend use of one model or the other.

2.0 Overview of the Models

Both the Research, Development and Acquisition Alternatives Analyzer and the Value Added Analysis models address the problem of recommending an optimized acquisition strategy. Yet these models approach this problem in different ways. In order to compare and contrast the approaches used, it is necessary to first briefly discuss the major features of each model. Additional detail for each model may be found in the references cited at the end of this technical report.

2.1 Research, Development & Acquisitions Alternatives Analyzer (RDA3)

The Research, Development and Acquisition Alternatives Analyzer (RDA3) is a combined valuation and optimization model for helping the Army program long-term capital expenditures. RDA3 recommends optimum candidate modernization investments by maximizing projected value, subject to a variety of constraints on mission area balances, funding trajectories, logical relationships among programs and other Army concerns [Anderson, et. al. 1993, abstract]. RDA3 is capable of evaluating all Management Decision Packages (MDEP) that are considered modernization candidates.

The RDA3 is a *two phase* decision support system. In *Phase 1* Satty's [1980] Analytic Hierarchy Process (AHP) is used to assign relative values to each Management Decision Package (MDEP) which is considered a modernization candidate. In *Phase 2*, the relative MDEP values derived in *Phase 1* are combined with a database that specifies the proposed annual MDEP funding increments. This information is then input into a multi-objective goal program which provides the necessary outputs to enable PAED action officers to recommend various courses of action. Figure 2.1 presents a simplified overview of the RDA3 decision support system (DSS). RDA3 will be discussed in more detail in subsequent paragraphs.

2.1.1 RDA3 - Phase 1 Process

Phase 1 begins with the gathering of necessary information. MDEP candidates are assigned a proposed funding structure. Projected annual RDA constraints are obtained from HQDA. Other considerations, in the form of allocation imperatives or goals are specified. The major product of *Phase 1* however is the determination of relative priority values for each MDEP using the hierarchical assessment portion of RDA3.

To assess the relative value of one MDEP modernization candidate in relation to others, a number factors must be considered. Issues such as warfighting contribution, costs, field experience, testing and evaluation results, COEA's, OSD and Congressional attitudes, business sense, etc.,

must be considered [Anderson, et. al., 1993, p.8]. This poses a very difficult problem. RDA3 uses an adaptation of Satty's [1980] Analytic Hierarchy Process (AHP) to obtain an Army-wide perspective on the potential value of a modernization candidate to the future Army.

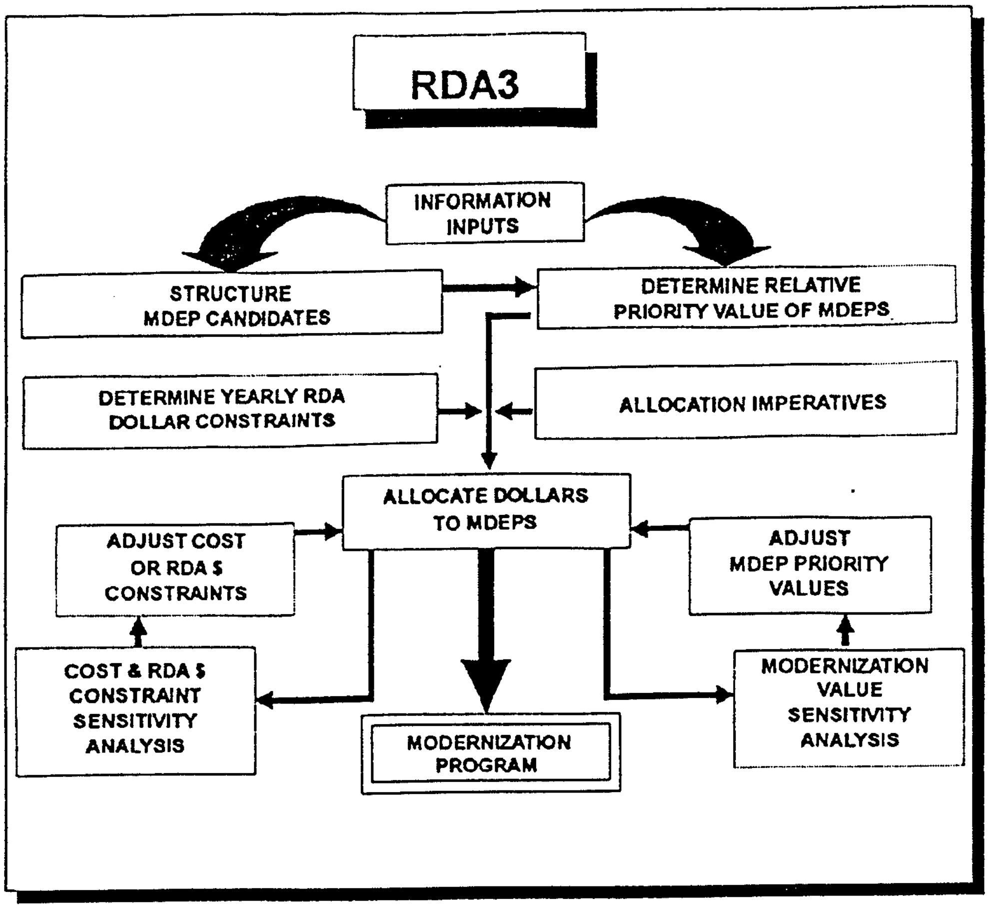

Figure 2.1 The RDA3 Process [Anderson, et. al., 1993, p.6]

AHP is a multi-criteria decision making process which has been used in a wide variety of settings to aid decision makers in planning, priority setting, and resource allocation. From a macro view point, AHP has three steps. First the problem is decomposed through the development of a hierarchical structure. This decomposition leads to the establishment of a number of criteria at each level of the hierarchy. In the second step, subject matter experts (SME) are asked to complete a survey. This survey consists of a number of judgment questions in which the SME is asked to judge the relative importance of each criteria (using an ordinal scale) through a series of pairwise comparisons. In the final step, a series of matrix calculations are performed using the input from the SME's to derive estimates of the relative value of candidate modernization systems. A thorough discussion of the AHP theory is contained in Saaty [1980].

The outcome of any application of AHP is very dependent on how the hierarchical structure is established. In RDA3 a five level hierarchy based on how Acquisition Support and Program Analysis Directorate (ASPAD) of PAED evaluates modernization systems is used (see figure 2.2). The top level is the focus of the overall effort, future Army modernization. This top level is decomposed into the 14 Army mission areas that ASPAD uses when considering modernization actions. Each mission area at the second level is decomposed into sub-mission areas. The collection of about 40 sub-mission areas comprises the third level of the hierarchy. At the fourth level, the modernization MDEP's are matched with the sub-mission areas which they support. The bottom level of the hierarchy is formed by breaking out the yearly incrementing structure of the individual MDEP's.

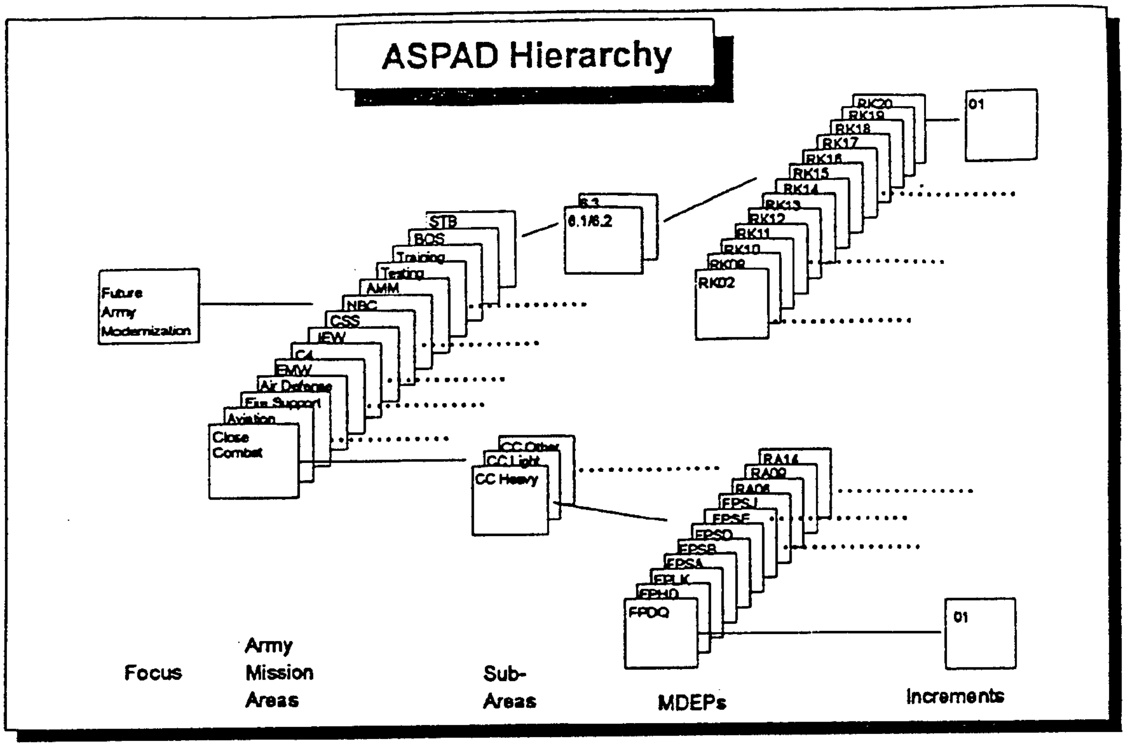

Figure 2.2 RDA3 AHP Hierarchical Decomposition Structure [Anderson, et. al., 1993, p.9]

The outcome of the AHP process is also affected by the SME population selected to complete the AHP surveys. In recent uses of RDA3 the ASPAD Director supplied judgments for the Army mission areas and sub-mission areas. ASPAD Action Officers supplied judgments of MDEP value relative to sub-mission areas. A more detailed discussion of the AHP implementation in RDA3 including examples of SME questions and the calculation of relative values is contained in Anderson, et. al. [1993].

2.1.2 RDA3 - Phase 2 Process

In *Phase 2* the relative priority values determined through the AHP process along with budgetary information gathered in *Phase 1* are placed into a multi-objective goal program. Through the use of this mathematical programming technique, RDA3 attempts to structure a set of MDEP increments that provides the greatest return on investment for the Army, subject to the investment dollars available and other constraints which affect the allocation of resources among competing alternatives [Anderson, et. al., 1993, p.16].

The goal programming model is formulated as a combination of goals and constraints. The goals represent target levels that the math program will attempt to achieve, while the constraints are mathematical conditions which must be met. The RDA3 optimization module attempts to satisfy the following goals: maximize value as derived from the hierarchical assessment process; allocate resources so as to maintain a balance of resources among the fourteen Army mission areas; minimize turbulence in the year to year funding profiles to prevent undesired fluctuating funding oscillations in the MDEP's [Anderson, et. al., 1993, p.16]. There are two types of constraints used in the optimization program: system constraints and logical constraints.

System constraints relate to boundary conditions for the solution. Examples of system constraints include: Congressional / DoD MDEP's are funded; yearly budgetary restrictions are achieved; basecase MDEP's are funded before considering additional increments; recommended funding for those MDEP increments "selected" achieves at least a minimum threshold level of funding; upper and lower bounds are maintained for the allocation of resources among the mission areas; a provision is made for specifying an upper bound on operations and support costs [Anderson, et. al., 1993, p.17].

Logical constraints ensure required relationships between MDEP's are met. Examples of logical constraints include: mutually supportive MDEP increments are funded together or in combination as sets; competing systems are modeled in mutually exclusive relationships so that no more than one system receives a funding recommendation; complex combinations of mutually supportive and competing MDEP's are selected in-line with decision maker wishes [Anderson, et. al., 1993, p.18].

The formulation described above is implemented using the General Algebraic Modeling System (GAMS) and is run on IBM PC compatible 386/486 computers. GAMS allows rapid changes in formulation of the problem. Solution times for problems may be arrived at in 10 - 20 minutes. The rapid formulation capability of GAMS makes it possible to perform sensitivity analysis by varying such considerations as, mandated MDEP increments, logical constraints, budgetary limitations, MDEP valuing, incremental funding thresholds, and goals for mission area funding levels

[Anderson, et. al., 1993, p.21]. A detailed description of the optimization module is contained in Donahue [1992].

2.2 Value Added Analysis (VAA)

The Value Added Analysis methodology developed from a perceived need to change the traditional way the Army has approached program development. Traditionally, program development has been accomplished during the Planning, Programming, Budgeting, and Execution System (PPBES) POM building process using functional or mission area panels. These panels often took a narrow view and optimized programs within their functional or mission area. Additionally, the panels have had the latitude to use their own methods of prioritization. This lack of standardization has prevented Senior Army Leadership from making effective trade-offs across functional areas.

The Value Added Analysis (VAA) methodology provides optimized acquisition strategies across system types, as well as other analysis to support decision making necessary to build the Army POM. *Value Added* is defined as the incremental return on investment as measured using effectiveness values compared to cost [Loerch, 1993]. The VAA methodology is built around six interrelated modules and uses a family of models to measure a modernization program's contribution to the overall program as an incremental or decremental change from the current program base.

The VAA process begins with the *Issue Definition Module* where systems / programs to be studied are identified and issues such as scenarios and timeframes are resolved. In the *Effectiveness Module* each programs effectiveness in the areas of deployability, sustainment and combat effectiveness is assessed. A detailed analysis of life cycle costs is performed for each system / program in the *Cost Module*. In the *Optimization Module* a cost-benefit analysis is performed using a mixed integer linear program optimization model to determine the most cost effective acquisition strategy for the candidate modernization systems. The effectiveness of this acquisitions strategy is modeled in a *Theater Force Evaluation Module*. Finally, in the *Results and Displays Module* analysis of results is conducted, reports and briefings for decision makers are prepared[Loerch, 1993]. Figure 2.3 shows the relationships between the VAA modules.

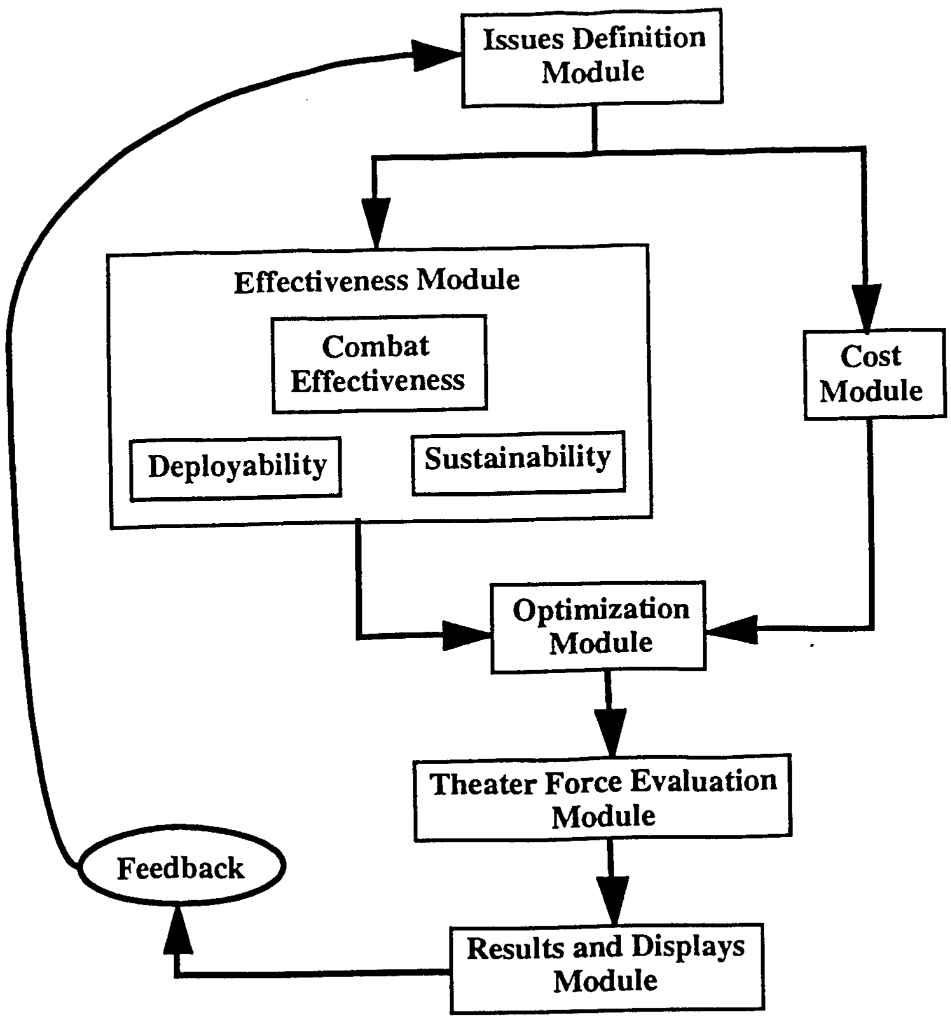

Figure 2.3 Value Added Analysis Modules [Loerch, 1993]

The VAA methodology has been developed and refined over the past four years and continues to be extended. In particular, the *Effectiveness Module* has been changed substantially. Formerly there were modules which addressed implicit effectiveness, explicit effectiveness and effectiveness integration. In the third VAA study, there will be only one Effectiveness Module in which the issues of system effectiveness in terms of deployability, sustainability and combat effectiveness will be addressed[1]. Additionally, in the coming year VAA will be used to examine not only RDA, but also Operations and Maintenance, Army (OMA) and other related appropriations as needed to investigate the full programming of selected major item systems. Finally, force structure alternatives and levels of training OPTEMPO will be examined for possible inclusion in the

[1]Phone Conversation by author with LTC Loerch, 12 Oct 93.

analysis. In the end, 70 - 80 systems should be examined through the VAA process in the next POM build.

2.2.1 VAA - Issue Definition Module

Issue definition is a process that continues for the duration of the Value Added Analysis. Through issue definition, the problem is refined so that data collection and analysis efforts are focused on the questions and issues of interest to decision makers. During issue definition, decisions must be reached concerning a number of factors which will effect analysis conducted in subsequent modules. These factors include: The timeframe of the study; The tactical scenarios used to evaluate the effectiveness of systems; The major item systems list -- the systems which will be evaluated; and the Measures of Effectiveness (MOE) which will be used in the effectiveness analysis. See Koury and Loerch [1992, p.3-1 to 3-3] for further details.

2.2.2 VAA - Effectiveness Module

Analysis performed during the *Effectiveness Module* assesses the contribution of a system / program to overall force effectiveness in terms of three issues: deployability; sustainability; and combat effectiveness. Each of these issues is evaluated through the use of appropriate models. Final decisions concerning which models should be used to evaluate deployability and sustainability have not yet been made. The Corps Battle Analyzer (CORBAN) is used to evaluate combat effectiveness.

The evaluation of combat effectiveness is used to measure the marginal increase or decrease in combat force level performance a candidate system brings to the total Army program. The Corps Battle Analyzer (CORBAN) is used to determine combat, combat support, and combat service support effectiveness. The specific scenarios and MOE's used are determined in consultation with decision makers during the issue definition process. Due to limited computing resources and time it is not possible to evaluate all candidate systems in all combinations in each year during both the POM period and the extended planning period (EPP)[2]. In previous uses of VAA, the evaluation time frame (which includes both the POM and EPP periods) was divided into the near-term (1st POM year), mid-term (last POM year) and far-term (last EPP year). Thus, each selected scenario is portrayed in each of the three time frames.

The ideal method for determining the optimal mix of new systems would be to explore all possible combinations. To attempt to do so, assuming 70 systems are to be evaluated, would require 2^{70} or 1.18×10^{21} runs per scenario-timeframe. This is clearly infeasible. VAA addresses this problem

[2]The EPP is a nine year period following the last year of the POM period.

through the use of a Plackett-Burman experimental design and response surface methodology for interpreting outputs. However, the amount of time needed to complete all runs for each scenario-timeframe is still substantial. See Koury and Loerch [1992, p.4-1 to 4-15] for additional detail.

The output of the analysis of deployability, sustainability and combat effectiveness is a vector of MOE's for each system. Saaty's [1980] AHP is used to construct a survey for Senior Army Leaders which is then used to determine the weighting scheme for the integration of the selected measures of effectiveness and scenario-timeframe combinations. The weights obtained from the Senior Leader Survey are used in an influence diagram whose output is the value added coefficients. The specific details of the implementation of this process are still being worked out by the VAA study team.

2.2.3 VAA - Cost Module

The purpose of the *Cost Module* is to provide accurate cost input to the *Optimization Module* that will result in reliable cost outputs for a wide range of applications. Weapon system cost-quantity relationships, weapon system categorizations, impacts on appropriations and formulation

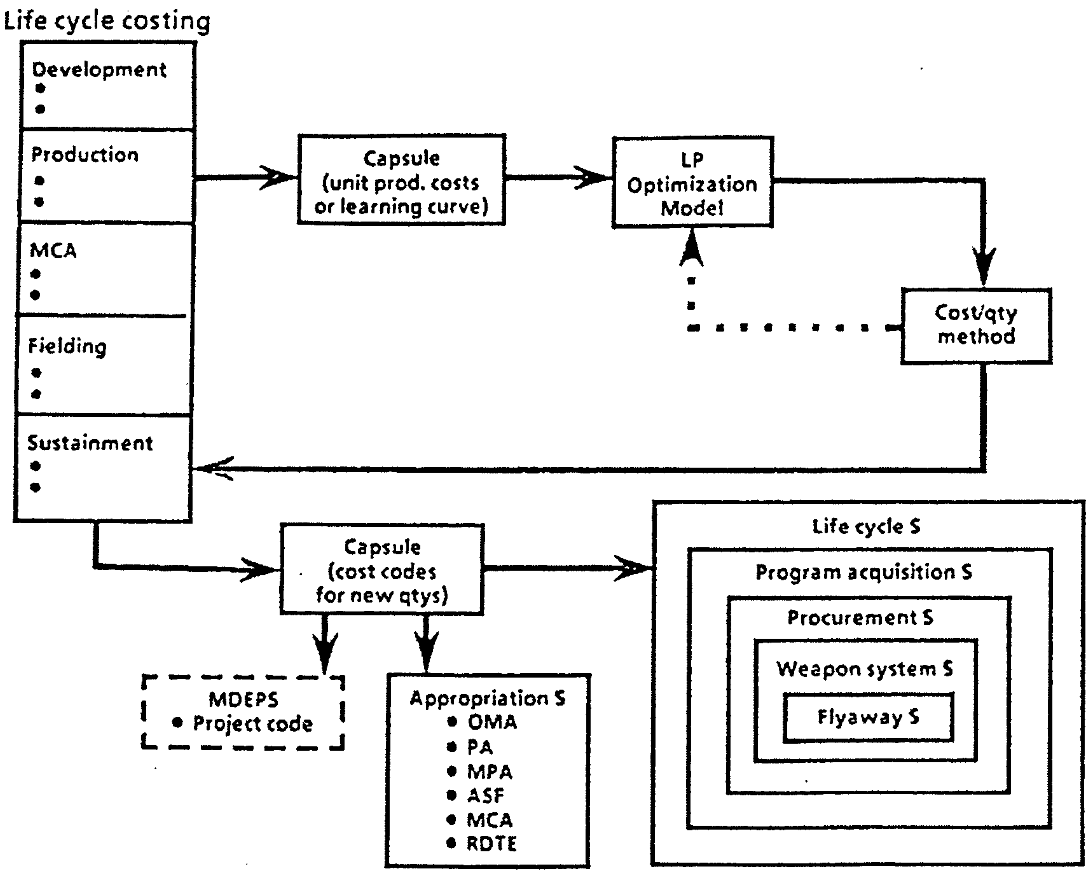

Figure 2.4 Overview of the VAA Costing Process [Koury and Loerch, 1992, p.7-1]

of budget constraints are considered in the costing process [Koury and Loerch, 1992, p.7-1]. Figure 2.4 provides an overview of the VAA costing process.

Baseline Research, Development, Test and Evaluation (RDTE) and procurement costs for VAA systems are provided as input to the VAA *Optimization Module.* With respect to procurement costs, systems are categorized as to whether or not cost-quantity curves (e.g. learning curves) are used. First unit costs and cost-quantity[3] curves are provided for those systems for which the data is available and applicable. Average unit procurement costs are used for the remaining systems. Life cycle costs are based on a baseline cost estimate P-92 cost code structure. Budget constraints are determined by applying a ratio, representing the proportion of Value Added Systems to the total RDA budget to a fixed TOA [Koury and Loerch, 1992, p. 7-1 to 7-2].

Cost data is obtained from a variety of sources including the US Army Cost and Economic Analysis Center (CEAC), Program Managers (PM), the Assistant Secretary of the Army for Research, Development, and Acquisition (ASARDA), Army Material Command (AMC) and the Office of the Deputy Chief of Staff for Operations (ODCSOPS). Most cost data is extracted from the Executive Summary of the Baseline Cost Estimate (BCE) or Army Cost Position (ACP). Additional details on the costing process may be found in Koury and Loerch [1992, Chapter 7 and Appendix E].

2.2.4 VAA - Optimization Module

The objective of the *Optimization Module* is to maximize the effectiveness of the force subject to constraints on budget, force structure, and production capability. The *Optimization Module* uses the Value Added Linear Optimization of Resources (VALOR) model as its principal tool [Koury and Loerch, 1992, p.8-1]. VALOR is a mixed integer linear program. The *Effectiveness Module* and *Cost Module* provide the necessary inputs to set-up the VALOR model. Recall, that in the *Effectiveness Module* a single measure of each system's contribution to the effectiveness of the overall force for each year the system will be in the force is computed. This measure is known as the system's value added coefficient.

Since modeling in the *Effectiveness Module* is performed at discrete points in the planning period, the value added coefficients are only computed for those years. VALOR requires a value added coefficient for each year a system could be procured. To solve this problem, the assumption was made that system effectiveness would vary linearly between the years in which the system is

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[3]Cost-quantity reflects economies of scale in terms of material and labor as opposed to exclusive learning on the part of the production labor force.

actually modeled. Linear interpolation is then used to calculate the value added coefficients for the years that were not modeled in the *Effectiveness Module.*

The objective function for VALOR is formed as follows. Let v_{ij} be the per-item contribution of the system to force effectiveness, and let x_{ij} be defined as the quantity of system i (of a total of m systems considered in the study) procured in year j, where $j=1, ..., n$, with n being the number of years in the planning horizon. The objective function can then be written as

$$Maximize \sum_{j=1}^{n} \sum_{i=1}^{m} v_{ij}\ x_{ij}$$

This objective function is subject to constraints which include: budgetary constraints; Total Obligation Authority; learning curve costs; nonlearning curve variable costs; consideration of fixed costs; force structure constraints; production constraints; and related system procurements. Additional details on VALOR may be found in Koury and Loerch [1992, Chap. 8] or the CAA Technical Paper on VALOR [CAA TP 91-7]. VALOR was implemented using the IBM Optimization Software Library on an IBM RISC 6000 work station. Run time for the 41 systems analyzed in the VAA Phase II study ranged from two to thirteen minutes.

2.2.5 VAA - Theater Force Evaluation Module

The *Theater Force Evaluation Module* is used to evaluate the effectiveness of a recommended acquisition strategy. In this module the systems recommended for procurement are distributed throughout the total force. This force is then simulated at the Theater Level to evaluate its effectiveness. This module has not been previously used in earlier VAA studies.

3.0 Comparisons and Contrasts

VAA and RDA3 were designed to address the problem of providing analytical support for system / program trade-offs during the process of building the POM. However, due to the different approaches taken in approaching this problem, the models differ in several ways. RDA3 and VAA differ in their respective resolution and breadth. They have significant differences in the methods they use to assess the relative value of the systems / programs which are being evaluated. They approach the issue of obtaining and using cost data from two very different viewpoints. Finally, the optimization modules have different objective functions, constraints and are using cost inputs derived from different sources.

3.1 Model Resolution and Breadth

RDA3 and VAA differ in both the amount of information or detail considered (*Resolution*) and in the number of systems which may be evaluated (*Breadth*). In general, VAA might be characterized as having greater resolution, but less breadth than RDA3. Resolution differences between the two models are seen mainly in three areas: costing; optimization; and effectiveness assessment.

The cost data used in the RDA3 model is aggregated and rolled up into a cost figure for each MDEP. The cost data used in the VAA model is much more detailed and the optimization module makes use of this extra information. Thus, VAA explicitly considers additional details, such as learning curve costs and production - quantity cost relationships that are not considered in the RDA3 model. Additionally, through the use of simulation and the resulting ability to perform analysis of the results, VAA is able to examine the effects of acquiring systems in greater detail than the subjective AHP process used by RDA3.

There is also a difference in the breadth of programs each model can be used to evaluate. RDA3 is capable of evaluating all RDA MDEP's. In recent uses RDA3 has been used to evaluate 329 MDEP's[4]. VAA is constrained by its *Effectiveness Module* and is only capable of addressing a subset of the RDA programs[5]. The specific systems to be analyzed in VAA are decided in consultation with the appropriate decision makers during the VAA *Issues Definition Module*. In the Phase III VAA study approximately 70 systems will be evaluated [Loerch, 1993].

3.2 Assessment of System/Program Relative Value

The two models have major differences in how they approach the assessment of relative value of systems. RDA3's assessment is based on an application of Saaty's [1980] Analytic Hierarchy Process applied to a survey of Subject Matter Experts from PA&E. This is necessarily a subjective approach. The VAA assessment is based primarily on analytical results obtained from simulations performed during its *Effectiveness Module*. The results of the various analytical studies are then combined using criteria value weights derived from a survey of Senior Army Leadership.

3.3 Costing

RDA3 and VAA approach the issue of system/program costing very differently. RDA3 is MDEP focused, while VAA is system / program focused. RDA3 obtains all costing data from MDEP's as listed in the Research, Development, and Acquisition Information System Agency (RDAISA)

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[4]Conversation with LTC Colter, PA&E, 8 Jul 93.

[5]Phone conversation with LTC Loerch, CAA, 7 Oct 93

database. The cost data used is aggregate cost data and is only broken out by MDEP increments[6]. VAA uses a great deal more cost data and draws it from a variety of sources. VAA draws most of its cost data from BCE and ACP estimates provided through CEAC. Additional cost information may be drawn from a wide variety of agencies, including AMC, ASARDA and ODCSOPS. This is detailed data which covers production costs, learning curve costs and detailed life cycle costs. The chief item to note is that VAA costing is not explicitly based on MDEP costing and is being drawn from different sources than the costing data used by RDA3.

3.4 Optimization

The optimization modules in VAA and RDA3 are also quite different. The RDA3 optimization module uses a multi-objective weighted linear goal program which attempts to find the best acquisition strategy which will simultaneously best satisfy the goals subject to the stated constraints. VAA's optimization module uses a mixed integer linear program which is formulated to maximize total force effectiveness subject to the stated constraints. More important perhaps than the type of Linear Program (LP) used by each model is the information used to form the objective function and constraints in the formulation of each LP.

As noted above, the cost data used by VAA and RDA3 are extracted from different sources, have different levels of detail and very likely do not agree exactly for similar systems. Note also, that VAA's optimization module makes use of cost data such as learning curve cost and quantity-production costs in deriving its optimum acquisition strategy that are not considered or modeled explicitly in RDA3. Another major difference in information inputs lies in the use of relative priority or effectiveness values for systems. RDA3 forms these values through the AHP survey process. VAA forms relative values through simulation studies in its *Effectiveness Module*.

A difference that will significantly affect the recommended optimum acquisition strategy is the formulation of each model's objective function. In RDA3, the objective function is formed as the simultaneous minimization of weighted and scaled deviations from the stated goals. Recall from the discussion in Section 2.1.2, that the RDA3 goals were to: maximize value as derived from the hierarchical assessment process; allocate resources so as to maintain a balance of resources among the fourteen Army mission areas; minimize turbulence in the year to year funding profiles to prevent undesired fluctuating funding oscillations in the MDEP's [Anderson, et. al., 1993, p.16]. In VAA the objective function is formulated to maximize total force effectiveness[7].

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[6]Yearly funding allocations for each budget or prgram year the MDEP covers.

[7]See Section 2.2.4 for the mathematical formulation of the VAA objective function.

The last major area that will affect the output of the optimization modules of VAA and RDA3 is the constraints formulated in each LP. In this area there are a number of similar constraints, but it is important to remember that the cost data being used in those constraints is derived from different sources. However there are also a number of differences. RDA3 sets up constraints that maintain balance across mission areas. This type of constraint is not used in VAA. VAA uses constraints which consider learning curve costs, nonlearning curve variable costs, consideration of fixed costs[8], and quantity-production costs which are not used in RDA3.

4.0 Conclusions

Given the differences between RDA3 and VAA discussed above it is highly unlikely that they would produce extremely similar acquisition strategies. The models differ significantly in their approach. They examine different numbers of systems, they assess relative value of systems differently, they draw cost data from different sources and use it at different levels of detail and they use different mathematical optimization formulations which consider different objective functions and constraints. This constitutes a substantial set of differences in their approach to solving the RDA program trade-off problem.

However it is possible that there could be substantial agreement between RDA3 and VAA. The principal input into the VAA objective function is the system VAA coefficient or its measure of contribution to force effectiveness as determined in the VAA *Effectiveness Module*. If this measure shows a high correlation with the subjective relative priority weights derived during RDA3's *Phase I* AHP survey, then substantial agreement between RDA3 and VAA would be more likely. This agreement assumes that the cost data used by VAA and RDA3 even though drawn from separate sources is fairly similar. The only method to test this possibility would be to apply both models to the same set of systems and then compare and evaluate the recommended acquisition strategies.

[8]These costs are not incurred on a per-unit basis, but rather on a program basis. They represent RDTE expenditures and nonrecurring fixed manufacturing costs. If a system is not procured significant savings may be accrued by recouping fixed costs funds that have not yet been spent.

5.0 References

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Appendix A - Glossary

ACP	Army Cost Position
AHP	Analytic Hierarchy Process
AMC	Army Material Command
ASARDA	Assistant Secretary of the Army for Research, Development and Acquisition
ASPAD	Aquisition Support, Programs Analysis Directorate, PAED
BCE	Baseline Cost Estimate
CAA	Concepts Analysis Agency
CEAC	US Army Cost and Economic Analysis Center
COEA	Cost and Operational Effectiveness Analysis
CORBAN	Corps Battle Analyzer
DoD	Department of Defense
DSS	Decision Support System
EPP	Extended Planning Period
GAMS	General Algebraic Modeling System
HQDA	Headquarters, Department of the Army
MDEP	Management Decision Package
MOE	Measure of Effectiveness
ODCSOPS	Office of the Deputy Chief of Staff for Operations
OMA	Operations and Maintenance, Army
OPTEMPO	Operational Tempo
ORCEN	Operations Research Center
OSD	Office of the Secretary of Defense
PA&E	Programs, Analysis and Evaluation Directorate
PAED	Programs, Analysis and Evaluation Directorate
PM	Program Manager
POM	Program Objective Memorandum
PPBES	Planning, Programming, Budgeting and Execution System
RDA	Research, Development and Acquisition
RDA3	Research, Development and Acquisition Alternatives Analyzer
RDAISA	Research, Development and Acquisition Information Systems Agency
RDTE	Research, Development, Test and Evaluation
RISC	Reduced Instruction Set Computer
SME	Subject Matter Expert
TOA	Total Obligation Authority

Appendix A - Glossary

TRAC-OAC	TRADOC Analysis Command-Operations Analysis Center
TRADOC	Training and Doctrine Command
VAA	Value Added Analysis
VALOR	Value Added Liner Optimization of Resources